Information system for psycho-diagnostics using the Schulte table*

Tetiana Hovorushchenko[1,*,†], Yurii Voichur[1,†], Olha Hovorushchenko[2,†], Vitaliy Bortnyk[1,†] and Houda El Bouhissi[3,†]

[1] *Khmelnytskyi National University, Institutska str., 11, Khmelnytskyi, 29016, Ukraine*
[2] *National Pirogov Memorial Medical University, Pirogova str., 56, Vinnytsya, 21018, Ukraine*
[3] *LIMED Laboratory, Faculty of Exact Sciences University of Bejaia, 06000, Bejaia, Algeria*

Abstract

One of the areas that needs automation and digitization is psychology, in particular psycho-diagnostics. That is why the use of specialized information systems and software for conducting psycho-diagnostic research is becoming increasingly relevant. A popular method for assessing reaction speed and attention is a simple but effective technique that is actively used in education, sports, medicine, and self-development – testing using the Schulte table. There is currently an urgent need for a comprehensive information system that implements the Schulte test with all the necessary functions. An analysis of known solutions has shown that most of them are highly specialized, focused on monitoring one specific skill or property, their interfaces are mostly basic and do not contain additional functions for saving statistics, integration with other services. Most of them lack the function of saving results, which means that for long-term progress tracking, the user will have to record the data themselves. Therefore, the development of a full-fledged information system with a Ukrainian-language interface that implements the Schulte test is relevant. This study is aimed at designing and developing such an information system. As a result of the study, a web-oriented psycho-diagnostics information system using the Schulte table was designed and developed, which allows the user to take the Schulte test in an interactive environment with flexible test parameter settings. The developed information system complies with the principles of goal orientation, modularity and structure, flexibility and scalability, reliability and fault tolerance, security and data protection, interoperability, usability, efficiency and optimality, standardization and documentation. The developed system allows generating analysis tables and exporting results, automatically records results and the time of their completion, provides detailed statistics, and allows tracking the progress of the user-respondent.

Keywords

psycho-diagnostics, Schulte table, information system, context diagram, conceptual model[1]

1. Introduction

Today, medicine is in particular need of digitization and the development of information systems and technologies. With the growing volume of medical information, the need for rapid decision-making and improved diagnostic accuracy, the use of modern digital technologies is becoming not just desirable, but vital. Automated patient record systems, telemedicine, artificial intelligence for analyzing images and diagnoses, electronic prescriptions, and real-time health monitoring all open up new opportunities for the quality and accessibility of medical services [1, 2]. Digitization also has a positive impact on management processes in medicine and significantly improves the efficiency of medical institutions [3].

One of the areas that needs automation and digitization is psychology, in particular psycho-diagnostics. This area requires speed, accuracy, and convenience in processing test results [4, 5].

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[1,*] Corresponding author.
[†] These authors contributed equally.
tat_yana@ukr.net (T. Hovorushchenko); voichury@khmnu.edu.ua (Yu. Voichur); govorusenkoo@gmail.com (O. Hovorushchenko); bvitalij777@gmail.com (V. Bortnyk); houda.elbouhissi@gmail.com (H. El Bouhissi)
0000-0002-7942-1857 (T. Hovorushchenko); 0000-0003-3085-7315 (Yu. Voichur); 0000-0001-6583-5699 (O. Hovorushchenko); 0009-0006-0634-5001 (V. Bortnyk); 0000-0003-3239-8255 (H. El Bouhissi)

That is why the use of specialized information systems and software for conducting psycho-diagnostic research is becoming increasingly relevant. The use of such solutions allows optimizing the testing process and ensuring the objectivity of results, as well as a detailed analysis of the dynamics of changes in cognitive skills over a certain period of time [6, 7].

Psycho-diagnostics as a branch of applied psychology has a long history, since the need to measure mental processes such as attention, memory, and reaction arose with the emergence of the first professions that required increased accuracy and speed of action [8].

A popular method for assessing reaction speed and attention is a simple but effective technique that is actively used in education, sports, medicine, and self-development – testing using the Schulte table [9].

The Schulte method was developed by German psychiatrist and psychotherapist Walter Schulte in the mid-20th century. However, in the context of rapid digital technology development, when the information load on people is growing every year, this technique remains relevant. Initially, the Schulte method was used in engineering psychology to measure the effectiveness and speed of operators' orientational and search movements of the eyes. Since then, the table has undergone numerous changes and additions. The basic Schulte table consists of 25 cells (5 vertically and 5 horizontally, there may be variations of 6x6, 7x7), randomly filled with numbers from 1 to 25 (there may also be letters). The task is to find and indicate/name the numbers in the correct order (ascending or descending) as quickly as possible using only the eyes, without pointing or speaking. The psychologist records the total time taken to complete the task and observes the behavior (gaze, concentration, attention fluctuations). The accuracy of time measurement is critical for correct psycho-diagnostics. Several attempts may be made in a row to assess attention stability and dynamics [9].

The Schulte table is used in psycho-diagnostics as a tool for assessing attention, distribution and switching of attention, visual perception, and the pace of mental activity. It is part of standardized psychological testing methods, especially in the field of professional selection (military, pilots, drivers, IT specialists) [10-12], neuropsychological diagnostics, and educational counseling [13]. The Schulte table allows you to assess the speed of visual information processing, distribution and concentration of attention, peripheral visual perception, fatigue and stability of attention, and reaction to a decrease in cognitive resources during repetition [14].

The traditional implementation of the Schulte test has a number of significant drawbacks that significantly affect indicators such as accuracy, objectivity, and scalability of results [7-9].

One of the main problems is the inaccuracy of time measurement. Even an experienced specialist cannot accurately record how much time a person spent searching for each specific number, especially when recording is done using a manual stopwatch. This creates potential errors that reduce the reliability of the obtained results.

Another problem is the lack of dynamic analysis. The traditional approach using a paper version or a primitive digital implementation does not allow tracking the user's progress over a certain period of time. Without automated storage of results, it is difficult to determine whether attention is actually improving and whether the number of errors is decreasing with each subsequent attempt. In addition, traditional implementations often do not provide such flexible settings. In most cases, the user is limited to a fixed table size and cannot set different timers, change test modes, or determine the acceptable number of errors.

One serious problem is the ignoring of errors. In the traditional version of the test, the user may accidentally press the wrong number or skip the correct number, and these actions are usually not recorded. This problem reduces the diagnostic value of the test, since the number and type of errors are important markers of attention.

Ultimately, even if the time taken is recorded, it is most often presented as a simple numerical value without further visualization. For effective user interaction, it is extremely important to have a visualization of changes. The absence of graphs and charts for a specific period of time complicates the interpretation of results and devalues an effective tool.

There is currently an urgent need for a comprehensive information system that implements the Schulte test with all the necessary functions – from generating tables to analyzing and exporting results, which will automatically record the results, provide detailed statistics, allow to track progress, and allow to export data for further analysis. In addition, the information system being developed must be of high quality to ensure stable and effective operation in real operating conditions [15]. At the same time, it must be resistant to vulnerabilities to ensure data security and protection against potential cyberthreats [16].

2. Literature review

One solution for digitizing psycho-diagnostics using the Schulte table is the mobile application "Schulte Tables – Speed Reading" from Yurkap, developed specifically for Android. This application provides users with a convenient way to work with Schulte tables using a mobile phone. Thanks to its simple interface, Ukrainian localization, and regular updates, the app has gained great popularity among users, as evidenced by its high rating on Google Play – 4.9 out of 5 based on over 1,300 reviews and over 50,000 downloads [17]. The main mode of this app is classic Schulte tables of various sizes, ranging from the standard 5×5 to more complex options, such as 6×6. You can work not only with numbers, but also with letters of the Ukrainian alphabet. The task remains classic – to find all the elements in the correct order as quickly as possible. All results are saved (the app keeps statistics on success), and you can view the best results, average completion time, and progress dynamics for a certain period. The program is completely free in its basic functionality. Despite all the advantages, there are several drawbacks. The app is officially available only for Android, so iOS users cannot use it. Also, despite the availability of several exercises, the app focuses exclusively on reading skills.

Schulte Table Online from BrainApps.io offers users the opportunity to work with classic Schulte tables without the need to install additional software (Figure 1). The main purpose of this web application is to develop peripheral vision, concentration, and information processing speed. Users can choose from three different games with different grid sizes, allowing them to adapt the complexity of the exercise to their level of training [9]. However, this web application has several drawbacks: there is no function for saving results, meaning that users will have to record the data themselves in order to track their progress over the long term. Another significant drawback is the inability to take tests without authorization.

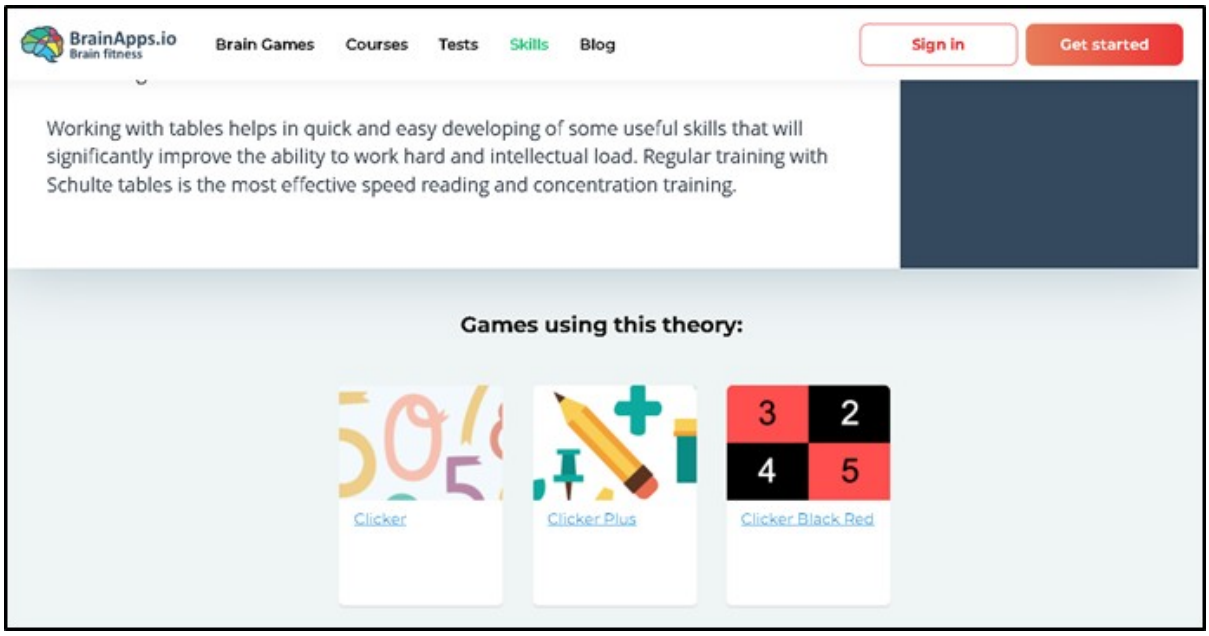

Figure 1: Window of the web application Schulte Table Online.

Open Schulte Table is a free, open-source desktop application available for both Windows and Linux (Figure 2). This software product implements the classic Schulte table method, where the user must find numbers in ascending order, focusing their gaze on the center of the table. The program also supports different grid sizes, allowing the complexity of the exercises to be adapted to the user's level. The interface is built using the Qt library, which provides cross-platform compatibility [18, 19]. The advantages are ease of use and the ability to run on different platforms. However, it should be noted that the program interface is quite basic and does not contain additional features such as statistics saving, various game modes, or integration with other services.

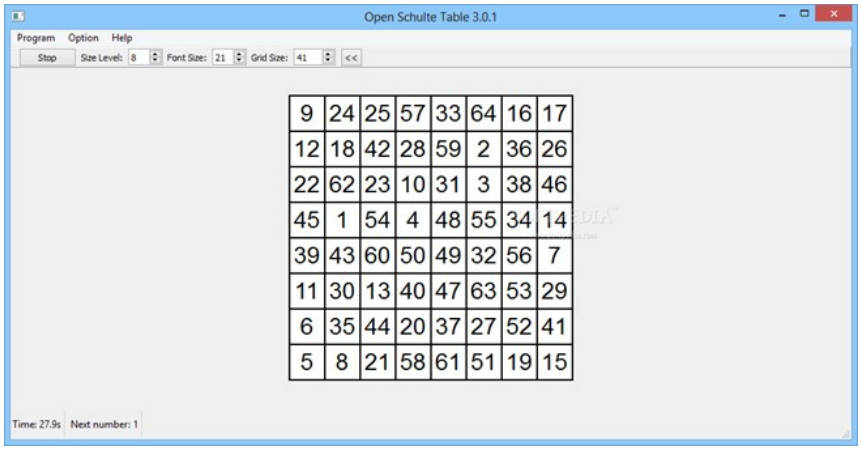

Figure 2: Window of desktop application Open Schulte Table.

In [20], the authors developed an information system for automated identification of operational personnel using the Schulte table based on the method of multidimensional average based on descriptive statistics of individual time series. The created system allows users to compare candidates and form their ratings.

The study [21] uses characteristics from data on mouse activity during the performance of the Schulte table task and creates a machine learning model to predict the subject's level of concentration.

Paper [22] develops a computerized battery for early, preclinical diagnosis of neurocognitive diseases (DiaNe), which can be used independently and performed using a tablet. DiaNe includes tests designed to assess basic cognitive areas (memory, attention, executive functions). DiaNe is a tool that provides both accuracy and reaction time measurement, designed to screen cognitive profiles.

Paper [23] presents a neurofeedback system for assessing mental attention and analyzing improvements in focused attention using Neurofeedback Space, a serious game tool.

Study [24] is devoted to the development of the Nesplora Aquarium program to assist physicians in assessing attention and working memory processes in adults aged 16 and older. It is an 18-minute individual test conducted using a VR system.

Research [25] presents the EpiTrack practical screening tool for assessing attention and executive functions when optimizing the effects of neurostimulation therapies on cognitive functions and when evaluating the impact of antiepileptic drugs.

The conducted analysis of known solutions has shown that most of them are highly specialized, focused on monitoring one specific skill or property, their interfaces are mostly basic and do not contain additional functions for saving statistics, integration with other services. Most of them lack the function of saving results, which means that for long-term progress tracking, the user will have to record the data themselves.

Therefore, the development of a full-fledged information system with a Ukrainian-language interface that implements the Schulte test is relevant. This study is aimed at designing and developing such an information system.

3. Design and realization of the information system for psycho-diagnostics using the Schulte table

Let's start designing the information system by building a contextual diagram of the functional model of the psycho-diagnostic information system, which uses the Schulte table as the main testing tool. The contextual diagram of the functional model of the psycho-diagnostics information system using the Schulte table (Figure 3) covers the interaction of three main subjects: the psychologist, the tested user, and external data storage/processing systems. The system receives input data from the respondent during the test, records the parameters, processes them, and transmits the results for analysis to the psychologist or exports them to external modules.

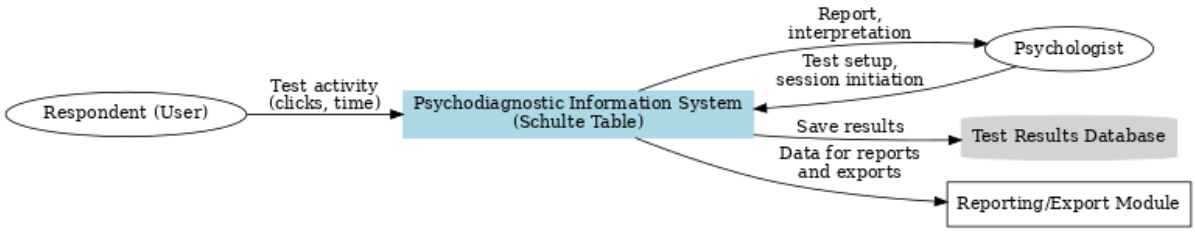

Figure 3: The contextual diagram of the functional model of the information system for psycho-diagnostics using the Schulte table.

Principles for developing an information system for psycho-diagnostics using the Schulte table:

- Goal orientation – the system is created for psychological testing based on Schulte tables, with the aim of diagnosing the level of concentration, visual perception, stability, and reaction speed. It must precisely meet the requirements of psychologists and researchers.
- Modularity and structure – the information system should consist of separate logical blocks to facilitate updating and expanding functionality.
- Flexibility and scalability – the system must support different table options (5×5, 6×6, etc.), allow for customization of complexity and test forms, and be scalable for use in different organizations.
- Reliability and fault tolerance – the information system must work correctly in the event of a session interruption, save intermediate results, and eliminate failures that could affect the reliability of the diagnosis.
- Security and data protection – respondents' personal data (if collected) and test results must be securely protected (user authentication, encryption, backup of results, access restrictions).
- Interoperability – the system must be able to export results in standardized formats, integrate with electronic accounting systems, psychological support logs, cloud services, etc.
- Usability – the interface must be simple and understandable for both the psychologist and the respondent in order to avoid influencing the test results.
- Efficiency and optimality – the system must respond quickly to user actions, without delays during testing. This is especially critical for accurate measurement of reaction time.
- Standardization – when creating the system, generally accepted standards for the storage and processing of medical and psychological data, as well as interface standards for better adaptation in educational and medical institutions, should be applied.

- Documentation – each module and function must be accompanied by technical documentation for further support, improvement, or transfer to other specialists.

Conceptual model of the information system for psycho-diagnostics using the Schulte table is presented in Figure 4.

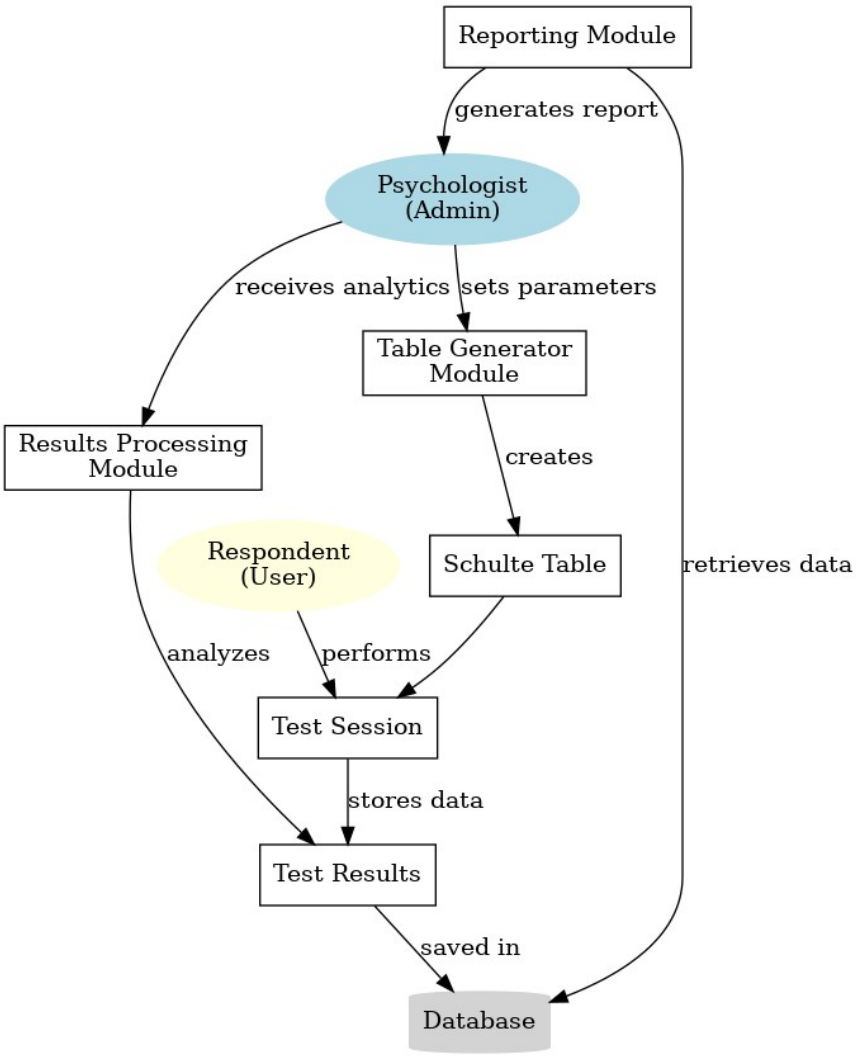

Figure 4: Conceptual model of the information system for psycho-diagnostics using the Schulte table.

For an information system for psychodiagnostics using the Schulte table, which has limited but clearly structured functionality, modular architecture is the most balanced and practical solution. It allows you to organize the code simply and logically, without complicating it with unnecessary abstractions. This architecture provides all the flexibility needed for further expansion – for example, for implementing analytics, reports, multi-user mode, etc. — without the need to rebuild the entire system.

JavaScript was chosen as the main implementation language for both the web interface and the server part of the information system. React was chosen to create the interface. NestJS was chosen as the server environment. Supabase was chosen to store structured information about users, sessions, and test results.

There are clear requirements for the database of the information system being developed, namely: support for structured storage of test sessions, the ability to record keystrokes, storage of pass parameters, provision of access to records, and further analysis of results. The choice of a

relational database is the most optimal for the task at hand. This type of storage allows for clear connections between entities, complex queries for data analysis, and guarantees reliability and scalability. Figure 5 shows the logical model of the database.

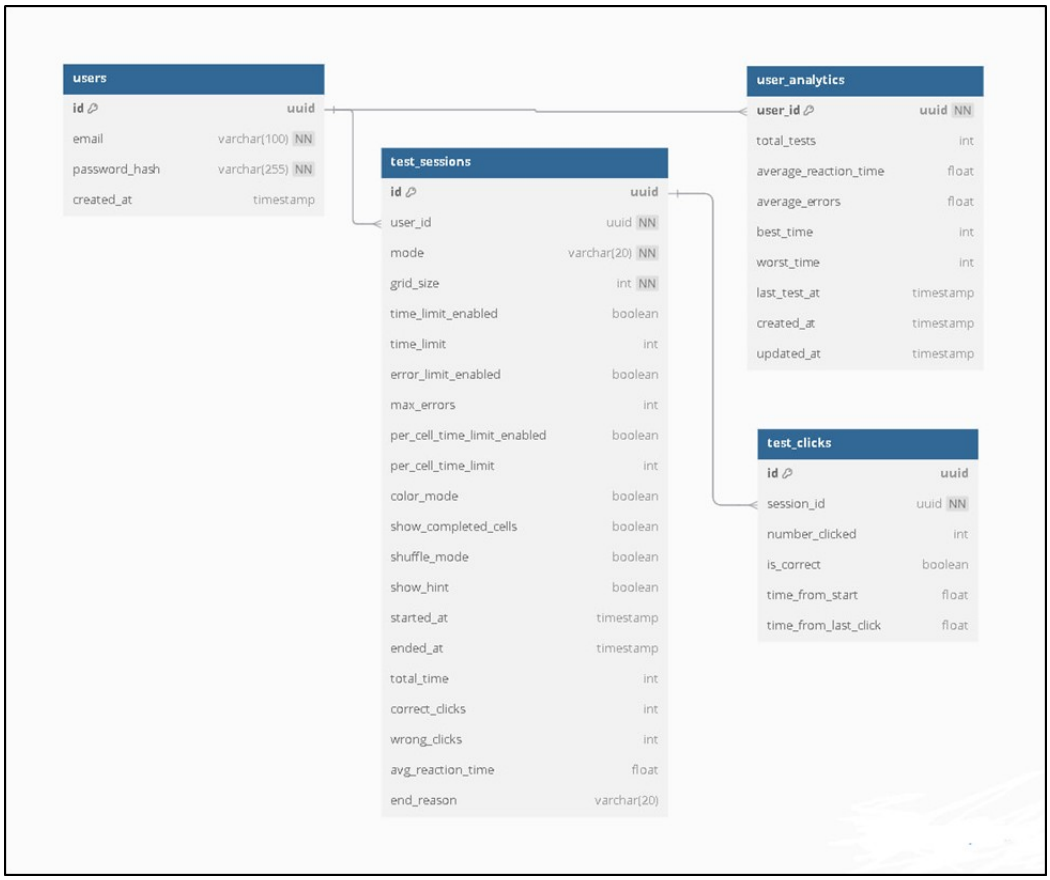

Figure 5: ER-diagram of the database of the information system for psycho-diagnostics using the Schulte table.

Given that a modular architecture was chosen for implementation, which will be implemented using the NestJS framework, the component diagram can be used to clearly display all the necessary modules that will be developed (Figure 6).

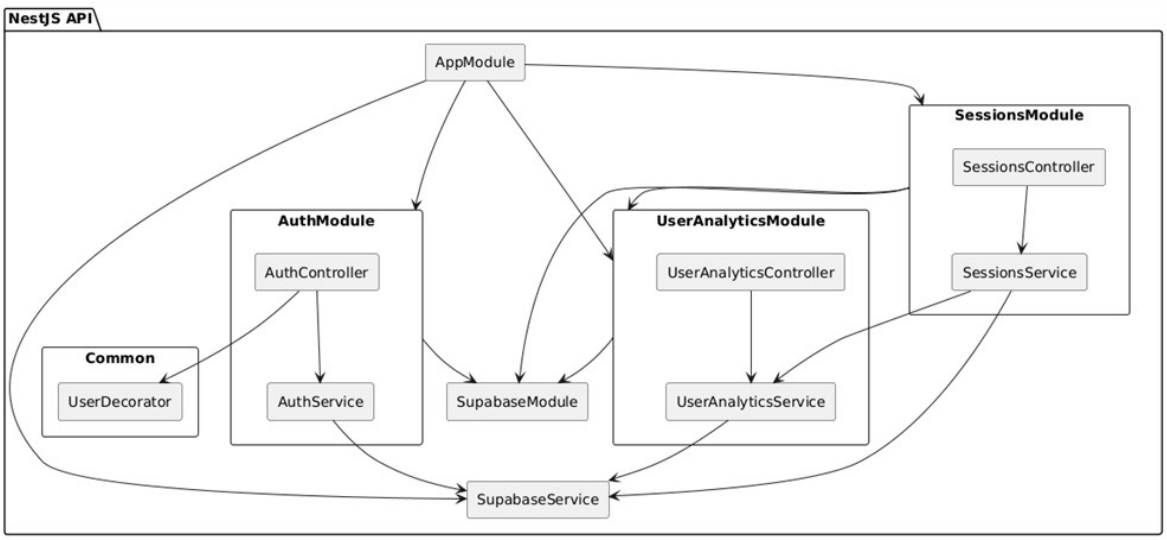

Figure 6: Component diagram of the information system for psycho-diagnostics using the Schulte table.

To ensure full interaction between the client side, database, and authorization mechanisms, it is necessary to develop the server side of the application using NestJS, which is a modern framework for Node.js that supports modular architecture and provides high scalability and structure for the project. The main tasks of the server side are to receive and process requests coming from the client side of the application, i.e., the web interface. In addition, the server logic is responsible for interacting with the Supabase database, performing read, write, and update operations according to the application logic. Another important component is user authorization verification. At this stage, the system analyzes the JWT tokens transmitted by the client and determines whether the user has the right to execute a specific request. The server part implements all the business logic of the project, such as aggregating test results, handling potential errors, and updating analytical data that reflects the dynamics of user results.

The SupabaseService service has been created, which encapsulates the logic of interaction with Supabase. In this service, the client is initialized using values from .env, and a method for verifying the JWT token is also implemented here. To make this and other services available in all parts of the application, it is moved to a separate SupabaseModule and exported. Swagger, a tool for automatically generating API documentation, is integrated. Using SwaggerModule, an interface is created that allows you to view all available routes, their methods, and examples of requests and responses. This simplifies the process of testing and developing the application.

After configuring the basic architecture, an authorization module was implemented, which will be responsible for registration, user login, and verification of user access to protected system resources. Requests are processed by the corresponding AuthService, which implements calls to Supabase via the signUp and signInWithPassword methods.

To structure the input data, the AuthDto class was created, which contains the email and password fields. Using decorators from the class-validator library, basic validation was added to the DTO, namely checking for the presence of a value, minimum password length, and email format compliance.

An important security element is the implementation of access control to protected routes. For this purpose, AuthGuard was developed, which analyzes the request header (Authorization: Bearer <token>), extracts the token, passes it to Supabase, and then checks its validity. If the token is invalid, the route will not be executed, and the system will return an authorization error.

The main task of the server part is to save the results of the Schulte test, which includes recording session parameters and detailed data about the user's clicks on the numbers. For this purpose, a separate SessionsModule module has been created, which implements the corresponding logic. This module has its own SessionsController, which contains the following routes: creating a new session (POST /sessions); viewing all user sessions (GET /sessions); viewing a specific test session (GET /sessions/:id); deleting a session (DELETE /sessions/:id). When creating a session, the client sends test parameters and an array of clicks, which will be transmitted in DTO format (CreateSessionDto and CreateClickDto). The SessionsService service will first create a session in the test_sessions table, then add clicks to the test_clicks table, linking them to the corresponding session. When requesting all sessions (GET /sessions), each of them also includes an array of related clicks, which allows the client to obtain complete information without additional requests.

In addition, the UserAnalyticsModule module has also been implemented, which provides statistical data processing, allowing you to display the average time, number of errors, best and worst results. After each completed test, the updateUserAnalytics() method will be called in the UserAnalyticsService service, which will automatically analyze and update the statistics. The controller of this module, UserAnalyticsController, implements a single GET /user-analytics/:userId route, which allows the client to obtain current analytical data by user ID.

The result is the following class diagram (Figure 7).

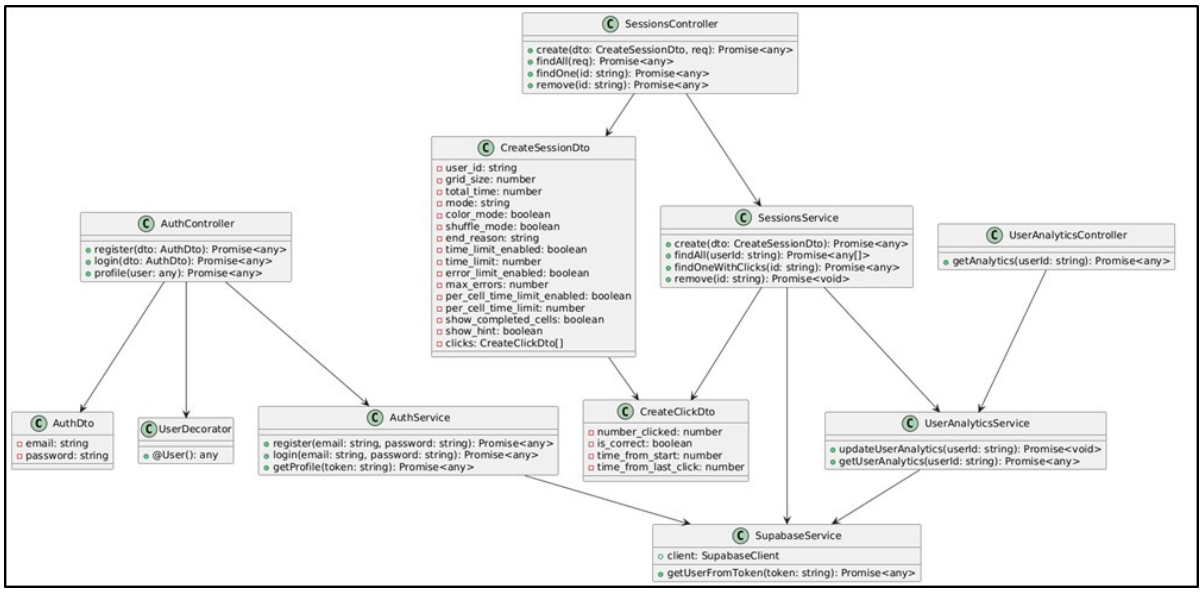

Figure 7: Class diagram of the information system for psycho-diagnostics using the Schulte table.

4. Results & discussion

Let's move on to creating a test page, which consists of the Schulte table itself and a panel that is used both for configuring the test and for displaying the test progress. A panel has been developed and imported into the test page (Figure 8).

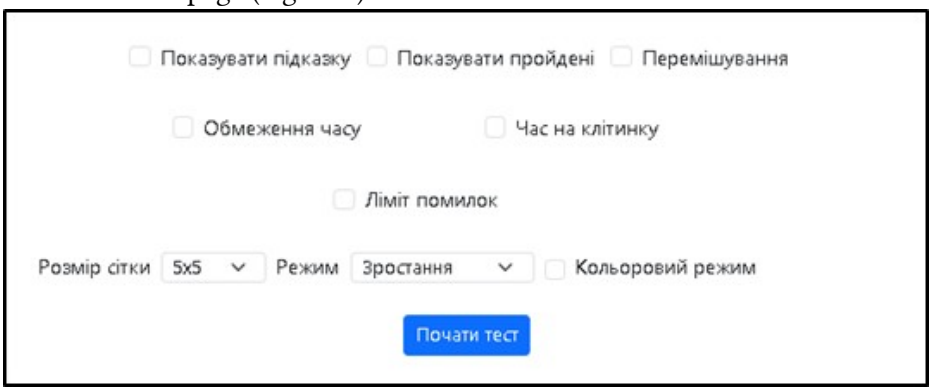

Figure 8: Window of the settings panel of the information system for psycho-diagnostics using the Schulte table (with a Ukrainian-language interface).

After writing the code for the main components of the page, they were imported directly into the TestPage.tsx test page file. This page also implements the logic of user interaction with the interface for the testing process, resulting in a page that contains all the necessary functionality (Figure 9).

An authorization form has been created, where can either log in to an existing account or register in the system. It should be noted that during development, data validation in the input fields must be taken into account (Figure 10).

The results of tests taken by authorized users are sent to the server for storage. A results page has been implemented, which contains analytics of user test results. This page consists of a block of general statistics, a table of results with the ability to filter and sort, as well as charts that visualize the results (Figure 11).

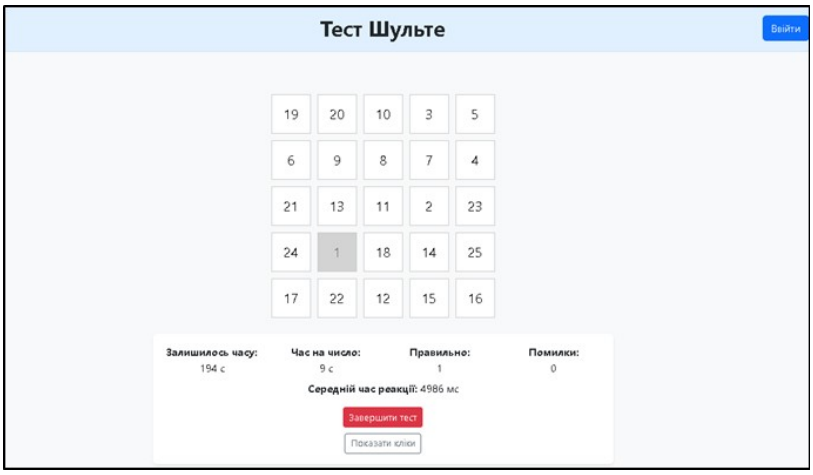

Figure 9: Window of the implemented testing page of the information system for psycho-diagnostics using the Schulte table (with a Ukrainian-language interface).

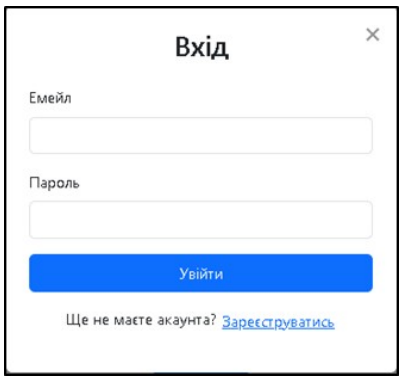

Figure 10: Window of the authorization form of the information system for psycho-diagnostics using the Schulte table (with a Ukrainian-language interface).

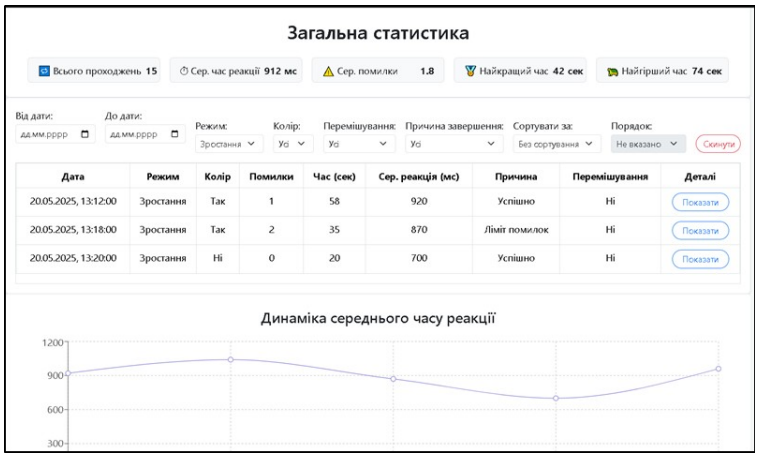

Figure 11: Fragment of the results page of the information system for psycho-diagnostics using the Schulte table (with a Ukrainian-language interface).

So, as a result of the study, a web-oriented psycho-diagnostics information system using the Schulte table was designed and developed, which allows the user to take the Schulte test in an interactive environment with flexible test parameter settings. The system interface is in Ukrainian and is built in accordance with UX/UI design principles, ensuring ease of use. Full integration with the API has been implemented, allowing test results to be transferred to the server.

5. Conclusions

One of the areas that needs automation and digitization is psychology, in particular psycho-diagnostics. A popular method for assessing reaction speed and attention is testing using the Schulte table. There is currently an urgent need for a comprehensive information system that implements the Schulte test with all the necessary functions. An analysis of known solutions has shown that most of them are highly specialized, focused on monitoring one specific skill or property, their interfaces are mostly basic and do not contain additional functions for saving statistics, integration with other services, etc., Most of them lack the function of saving results, which means that for long-term progress tracking, the user will have to record the data themselves. Therefore, the development of a full-fledged information system with a Ukrainian-language interface that implements the Schulte test is relevant.

As a result of the study, a web-oriented psycho-diagnostics information system using the Schulte table was designed and developed, which allows the user to take the Schulte test in an interactive environment with flexible test parameter settings. The developed information system complies with the principles of goal orientation, modularity and structure, flexibility and scalability, reliability and fault tolerance, security and data protection, interoperability, usability, efficiency and optimality, standardization and documentation. The developed system allows generating analysis tables and exporting results, automatically records results and the time of their completion, provides detailed statistics, and allows tracking the progress of the user-respondent.

Declaration on Generative AI

During the preparation of this work, the authors used Grammarly in order to: grammar and spelling check; DeepL Translate in order to: some phrases translation into English. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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